ExxonMobil Global Outlook
Executive Summary
Our view to 2050

ExxonMobil

The world in 2050 will be different

There will be billions more people, more prosperity, and more energy. Emissions will decline as a variety of low-carbon solutions advance, but achieving net-zero emissions will require the adoption of constructive policies, the emergence of new technologies, and the establishment of market-driven mechanisms.

The world may be different then, but the need to provide the reliable, affordable energy that drives economic prosperity and better living standards, while reducing greenhouse gas emissions, will remain just as critical as it is today. This will include oil and natural gas, which will still be required to drive critically needed economic growth in the developing world.

Every day, billions of people around the world benefit from the ability to heat and cool their homes, cook their food, access medical equipment and modern medicine, and travel for work and pleasure. Affordable and reliable energy is at the core of every key measure of human development – elevating living standards, life expectancy, education, and income per person. Yet for billions of more people, modern living conditions are still far out of reach.

In developing countries, such as India, gross domestic product (GDP) per person is only about $2,000 per year[1], and many people earn far less and lack access to basic necessities, including clean drinking water, heat, and cooking fuel. This challenge will only grow as the world's population increases from about 8 billion people today to nearly 10 billion in 2050 – a rate of about 1 million people every six days. And just as human progress has been fueled by higher energy use, further expansion of economic prosperity will depend on increased access to abundant, affordable energy.

Energy use and economic development are inseparable. Where there is energy poverty, there is poverty. And where energy availability rises, living standards rise as well.

China provides a great illustration. Over the past two decades, China's GDP per capita surged from around $2,000 to more than $11,000 and drove the elevated living standards that accompany this growth. At the beginning of this period, the basic energy needs of China's people weren't being met – the definition of "energy poverty." But 20 years later, China's energy use per person had nearly tripled, fueling massive economic expansion.

Between now and 2050, developing countries will see GDP per capita more than double, driving higher demand for energy. Meeting that demand with lower-emission energy options is vital to making progress toward society's environmental goals. At the same time, failing to meet demand would prevent developing nations from achieving their economic goals and their citizens from living longer, more fulfilling lives.

The critical question is how that growing energy demand will be met. Renewable energy continues to hold great promise, and we see wind and solar providing 11% of the world's energy supply in 2050, five times today's contribution. Other lower-emission options, such as biofuels, carbon capture and storage, hydrogen, and nuclear, will also play important roles. And even with this unprecedented rise in lower-emission options, oil and natural gas are still projected to meet more than half (54%) of the world's energy needs in 2050.

As lower-emission energy options grow, we project the world's energy-related CO_2 emissions will decline by 25% by 2050.

As lower-emission options grow, we project the world's energy-related CO_2 emissions will decline 25% by 2050. That's a major change as these emissions rose by 10% over the past decade. While the progress is substantial, larger reductions are needed to keep global warming from exceeding 2° Celsius, according to the United Nations Intergovernmental Panel on Climate Change (IPCC).

The world will need to dramatically scale up lower-emission solutions – beyond the current trajectory – that preserve the advantages of today's energy system while significantly and efficiently reducing emissions. Doing this will require policy support from governments, significant advances in technology to reduce costs, and ultimately, market-driven solutions to incentivize emission reductions.

How we develop the Outlook

ExxonMobil's Global Outlook is our latest view of demand and supply dynamics through 2050. It forms the basis for the company's business planning and is underpinned by a deep understanding of long-term market fundamentals. In addition to assessing trends in economic development, technology advances, and consumer behavior, the Outlook seeks to identify potential impacts of climate-related government policies.

ExxonMobil considers a range of scenarios – including those we view as remote – to help inform strategic thinking. No single pathway can be reasonably predicted, given the wide range of uncertainties. Key unknowns include yet-to-be-developed government policies and advances in technology that may influence the cost, pace, and potential availability of certain pathways. What also remains uncertain is how quickly and to what extent businesses and consumers will be willing to pay for deeper carbon reductions in the products and services they use, thereby creating a market that incentivizes an accelerated path to net zero.

Unlike the company's Outlook, which is a projection, many scenarios, such as International Energy Agency's Net Zero Emissions (IEA NZE) by 2050, work backward from a hypothetical outcome to identify the factors needed to achieve that outcome. It is important to note that the IEA acknowledges that society is not on a net-zero pathway, and that the NZE scenario assumes unprecedented energy efficiency gains, innovation and technology transfer, lower-emission investments, and globally coordinated greenhouse-gas reduction policy by governments.

A world with more people and more prosperity

The starting place for any assessment of global energy and product needs in 2050 is how many people there will be on the planet and how prosperous they will be.

The global population is projected to rise by 2 billion people, a 25% increase. It took thousands of years for the world to reach the first 2 billion people, which happened around 1930[2] – the next 2 billion is predicted to take around 30 years.

Not only will there be more people, but they will have greater opportunity and prosperity. Global GDP per capita – measured as purchasing power per person – is expected to rise by roughly 85% by 2050.

Those who live in developed countries are projected to see purchasing power rise roughly 50% to around $70,000. Most of the world's people live in developing countries (non-OECD) and are projected to see purchasing power more than double to $25,000. While this growth projection is impressive, people in the developing world would still have far less purchasing power in 2050 than people in developed nations have *today*.

2B

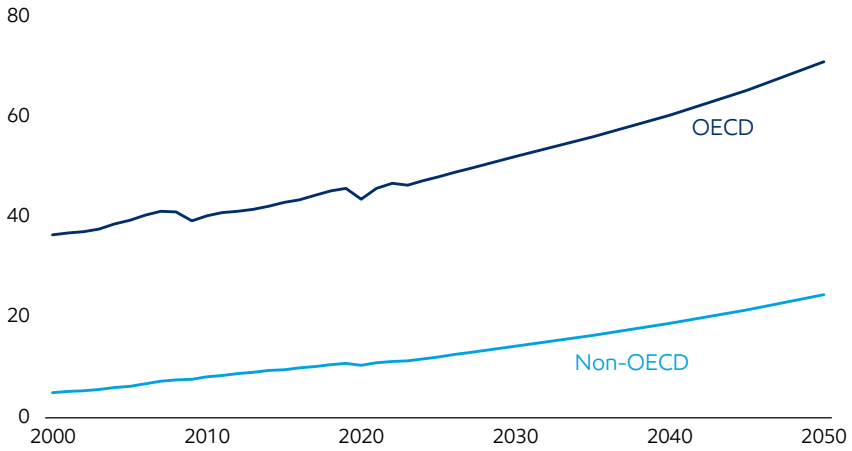
more people on the planet in 2050

85%

increase in purchasing power per person out to 2050

Purchasing power per person

Thousand PPP 2017$



OECD: Organization for Economic Cooperation and Development, a group of more affluent democracies with market-based economies that promotes economic growth

Powering human progress

Energy use and improved living standards go hand in hand. You can't have one without the other.

When China's per capita GDP was around $2,000, its energy use was low – about 36 million British thermal units (MMBtu) per person per year, deep in the realm of energy poverty.

By 2021, when per capita GDP passed $11,000, China's energy use had risen to 101 MMBtu per person, well above the global average.

In contrast with China, Africa's energy use per person has remained at a low 27 MMBtu for the past two decades, and its per capita GDP has only risen by about $500 during that time. Areas that remain mired in energy poverty struggle to raise the living standards of their people.

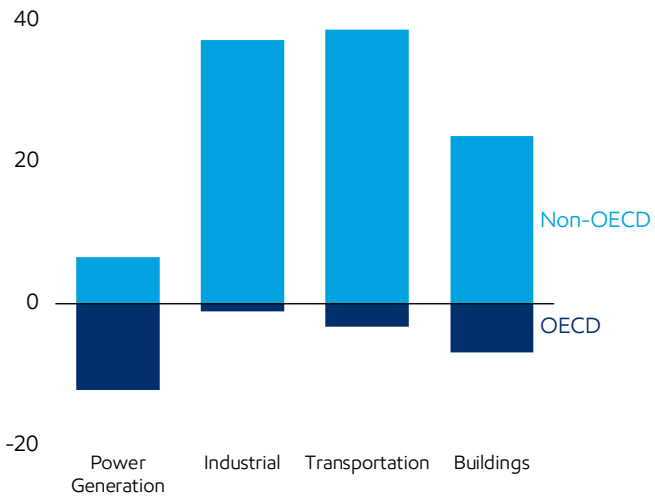
As we look ahead to 2050, how much more energy must the world produce to meet the needs of 2 billion additional people and a global economy that has doubled in size? About 15% more, according to our projection – with nearly *all* of it going toward meeting the higher living standards of a developing world with a larger population.

The dramatic expansion in population and per capita GDP in non-OECD countries will require a significant increase in energy use. As noted, reducing energy poverty leads to a corresponding reduction in absolute poverty.

Contrast that with the developed world, where there will be little population growth, and greater efficiency is projected to cause energy use to decline across all sectors of the economy.

Nearly all growth in energy use will go toward raising living standards in the developing world.

Global energy growth, 2021-2050
Quadrillion Btu



All energy types needed to raise living standards and reduce emissions

The Global Outlook projects that the biggest change in the world's energy mix between now and 2050 will be a significant increase in solar and wind, along with a significant reduction in coal.

Energy from solar and wind is projected to more than quintuple, from 2% of the world's supply to 11%. Coal will increasingly be displaced by lower-emission sources of electricity production – not just renewables but also natural gas, which has about half the carbon intensity of coal. Overall, electricity use grows 80% by 2050.

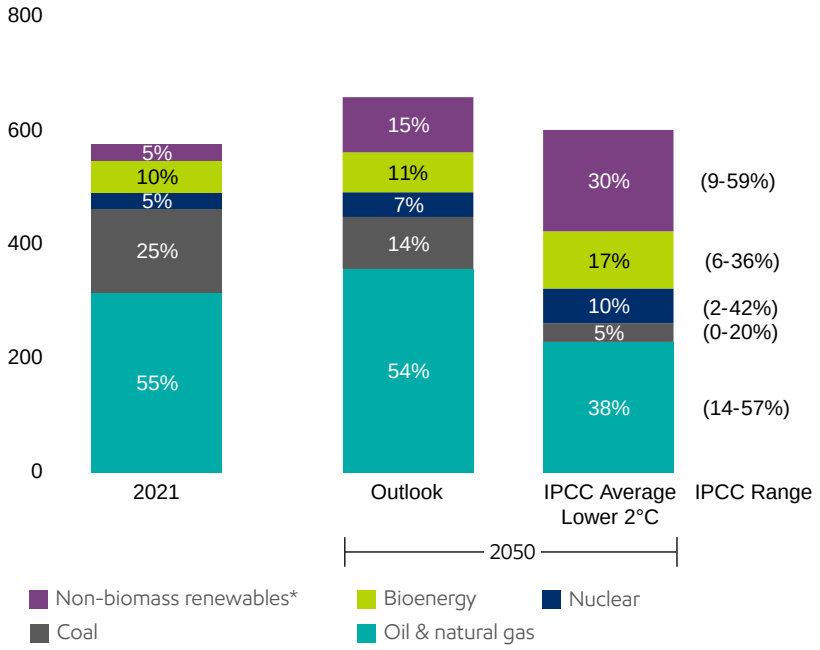
Oil and natural gas are projected to still make up more than half of the world's energy supply. The utility of oil and natural gas in meeting the world's needs remains unmatched. They are energy dense, portable, available, and affordable — and serve as essential raw materials for many products we use today. Given that oil and natural gas are projected to remain a critical component of a global energy system through 2050, sustained investments are essential to offset depletion as production naturally declines by 5-7% per year.

Oil use is expected to decline significantly in personal transportation but will remain essential for the industrial processes and heavy-duty transport like shipping, long-haul trucking, and aviation that underpin economic growth. Consider: If every new passenger car sold in the world in 2035 were an electric vehicle, oil demand in 2050 would still be 85 million barrels per day, the same as it was around 2010.

Natural gas use is projected to increase by more than 20% by 2050 given its utility as a reliable and lower-emissions source of fuel for electricity generation, hydrogen production, and heating for both industrial processes and buildings.

Global energy mix

Quadrillion Btu



* Includes hydro, wind, solar, and geothermal

Source: IPCC: AR6 Scenarios Database hosted by IIASA release 1.0 average IPCC C3: "Likely below 2°C" scenarios; ExxonMobil analysis

Emissions are falling – but more is needed to reach 2°C

Even in a higher-energy future, the rise of renewables, decline of coal, and improvements in energy efficiency mean the world will produce far fewer carbon emissions than it does today.

Overall, energy-related CO_2 emissions are projected to peak at more than 34 billion metric tons sometime this decade and then decline to 25 billion metric tons in 2050. The world's ability to reduce these emissions by 25%, even as the global economy grows by more than 100%, is a testament to the significant progress expected to be made.

Even so, more is needed to hit the emission-reduction levels required to keep global temperature increases below 2°C. The average of the IPCC's Lower 2°C scenarios requires emissions to fall to around 11 billion metric tons by 2050[3].

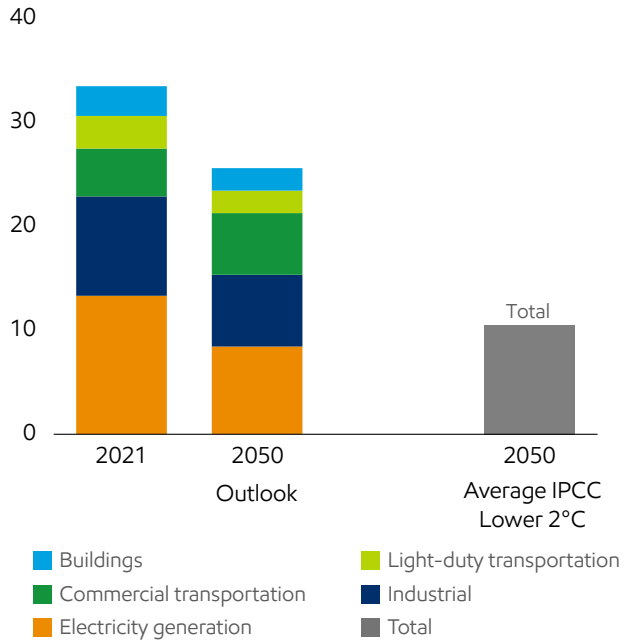
Because energy demand will increase in 2050 to support the economic growth of the world's developing nations, an abundant supply of energy-dense fuels will remain imperative. Fossil fuels remain the most effective way to produce the massive amounts of energy needed to create and support the manufacturing, commercial transportation, and industrial sectors that drive modern economies. For this reason, a critical goal of any energy transition will be the affordable decarbonization of these economic sectors that account for half of all energy-related emissions.

Three scalable technologies hold significant promise for hard-to-decarbonize sectors in IPCC Lower 2°C scenarios:

- **Carbon capture and storage** is a proven and safe technology that reduces emissions from manufacturing and power generation. CO_2 emissions are captured, transported by pipeline to suitable geologic formations, and permanently stored deep underground. Carbon capture can also serve as a *negative* emissions technology that removes CO_2 from the atmosphere – a critical solution in many IPCC Lower 2°C scenarios and one that has been endorsed by the European Union, U.S. administration, and the United Nations.
- **Hydrogen** is a fuel that, when combusted, produces only water as a byproduct. One way to produce low-carbon hydrogen is to convert natural gas into hydrogen and CO_2 – the hydrogen is used as fuel, while the CO_2 is captured and stored. Other sources of low-emission hydrogen involve using electricity from nuclear or renewables to split water molecules into hydrogen and oxygen.
- **Biofuels** can be a drop-in substitute for fossil fuels in a low-emissions manner on a life-cycle basis. Particularly useful in commercial transportation, biofuels return to the atmosphere the CO_2 that was absorbed during the growing process, thereby making them a low-carbon alternative.

Energy-related emissions

CO_2 Billion metric tons



Source: IPCC: AR6 Scenarios Database hosted by IIASA release 1.0 average IPCC C3: "Likely below 2°C" scenarios; ExxonMobil analysis

Emissions do not contain industry process emissions or land use and natural sinks

Three drivers will accelerate the energy transition

An energy transition is underway, but it is not yet happening at the scale or on the timetable required to achieve society's net-zero ambitions. Three key drivers are available, all involving broad collaboration among governments, companies, universities, and others.

First, continued **public policy support**. Incentives like those in the U.S. Inflation Reduction Act can provide the necessary catalyst to begin scaling up low-carbon solutions. Permitting reform is needed to accelerate the deployment of these solutions, a factor recognized in the European Union's Net-Zero Industry Act. Other policy priorities include enhanced transparency so that market participants have sufficient time to adapt to changes, and a recognition of the importance of keeping supply matched with demand to help minimize economic hardships on consumers.

Second, **technology advances**. Currently, only two of the 55 technologies needed to reach net-zero emissions by 2050 are "on track," according to the International Energy Agency[4]. An all-of-the-above approach to technology, where governments avoid picking winners and losers, will lead to the most cost-efficient solutions produced in a timely manner.

And third, **market-driven solutions**. Governments across the world can't afford to pay in perpetuity to reduce the amount of emissions needed to be removed or avoided. Ultimately, to achieve global emission-reduction goals, the world will need to move to widespread adoption of markets where society as a whole incentivizes driving emissions down.

The world has made meaningful progress. Even with ongoing economic development, the emissions intensity of the world's energy supply has declined since the Paris Agreement was signed in 2016. On the policy front, incentives for wind and solar catalyzed rapid deployment and cost reductions. Technologically, breakthroughs in shale enabled natural gas to disrupt and displace coal. And new markets for solar were created for both residential and utility-scale. Given the need to do more and do it faster at a lower cost, progress will need to occur in parallel, supported by policies that are technology-agnostic and incentivize all approaches, equally. Multiple approaches, nurtured by public-private partnerships and cross-industry collaboration, will be needed.

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Forward-looking statement

This Executive Summary of the Global Outlook includes Exxon Mobil Corporation's internal estimates of both historical levels and projections of challenging topics such as energy demand, supply, and trends through 2050 based upon internal data and analyses as well as publicly available information from many external sources including the International Energy Agency. Separate from ExxonMobil's analysis, we discuss a number of third-party scenarios such as the Intergovernmental Panel on Climate Change Lower 2°C and the International Energy Agency Net Zero Emissions by 2050 scenarios. Third-party scenarios discussed in this report reflect the modeling assumptions and outputs of their respective authors, not ExxonMobil, and their use and inclusion herein is not an endorsement by ExxonMobil of their results, likelihood or probability. Work on the Outlook and report was conducted during 2022 and early 2023. The report contains forward looking statements, including projections, targets, expectations, estimates and assumptions of future behaviors. Actual future conditions and results (including energy demand, energy supply, the growth of energy demand and supply, the impact of new technologies, the relative mix of energy across sources, economic sectors and geographic regions, imports and exports of energy, emissions and plans to reduce emissions) could differ materially due to changes in economic conditions, the ability to scale new technologies on a cost-effective basis, unexpected technological developments, the development of new supply sources, changes in law or government policy, political events, demographic changes and migration patterns, trade patterns, the development and enforcement of global, regional or national mandates, changes in consumer preferences, and other factors discussed herein and under the heading "Factors Affecting Future Results" in the Investors section of our website at www.exxonmobil.com. This material is not to be used or reproduced without the permission of Exxon Mobil Corporation. All rights reserved.

Endnotes

[1]The baseline year throughout this document is 2021 and applies to all references to "today," "current" and any other reference that is in the present tense. The Outlook was published in August 2023 with modeling work performed in 2022 and early 2023.

[2]https://www.weforum.org/agenda/2019/07/populations-around-world-changed-over-the-years/

[3]All "lower 2C°" references in this document are to: IPCC: AR 6 Scenarios Database hosted by IIASA release 1.0 average IPCC C3: "Likely below 2°C" scenarios

[4]https://www.iea.org/reports/tracking-clean-energy-progress-2023

* All $ amounts are in $USD